Weeds: a brief introduction

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Abstract
Many plants that are now recognised as weeds are incredibly beautiful and it is no wonder they have been used to adorn home gardens. Unfortunately, they can naturalise in the environment once they have escaped and cause many problems. Ornamental species form about two thirds of our environmental weeds. This paper outlines why weeds are a problem, the characteristics that allow weeds to become a problem and provides a brief glimpse of the mode of introduction of weeds to Australia. (*The Victorian Naturalist* **127** (4) 2010, 96–103)

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Introduction

This paper provides a brief overview of weeds or pest plants. It identifies that some people may value a plant while others see it as a pest, highlighting that the definition of a weed is labile. The paper provides a short account of the characteristics often associated with weeds, some of the problems that weeds cause and a brief account of why weeds were introduced into Australia.

What is a weed?

There is no denying that many weeds are very beautiful (Figs. 1-4 and front cover) and add to the diversity of colour and form during the 'wildflower' season, so it is no wonder that many tourists do not distinguish between weeds and native plants. A number of Victorian tour-bus drivers have asked the author what the fields of beautiful purple flowers are in agricultural land along the Hume Highway during spring-summer; the answer is Paterson's Curse *Echium plantagineum* (Fig. 6). This plant contains pyrolizidine alkaloids, which are toxic, and have resulted in the death of horses and cattle upon occasion, and costs agriculture $30 million each year (Groves *et al.* 2005) in control activities and loss of production. Paterson's Curse, however, is valued highly by beekeepers; so, is it a weed? The beekeepers fought, and lost, a court battle in the late 1980s to determine whether a biological control program should be implemented.

The term 'weed' has been variously defined as:

- any useless, troublesome or noxious plant (Emmerson and McCulloch 1994);
- an organism that diverts energy from a direction desired by man (Harlan and de Wet 1965);
- a plant growing out of place (Davies 1992);
- any plant growing where it is not wanted (Hussey *et al.* 1997);
- a plant whose virtues have not yet been discovered (Emerson 1878);
- a plant that interferes with man's use of land for particular purposes, with his well-being or with the quality of his environment (Buchanan 1989).

Other terms such as 'exotic', 'alien', 'naturalised' or 'introduced' often are used as a substitute for 'weed' as are 'feral' and 'pest'. The definition of a weed, thus, is contextual and can vary in time and space. Certainly, many plants now considered weeds in Australia have proven useful in the past for food, medicine, provision of building materials and fodder for animals and still are used elsewhere in the world. For example, Fat-hen or Goosefoot *Chenopodium album* currently is used as a vegetable and/or a medicine in Nepal, India (Grubben and Denton 2004) and Africa (Ruffo *et al.* 2002), and was used in Australia as a spinach substitute by the early settlers (Low 1988). Today in Australia, it is considered a weed of crops, wasteland, and other disturbed sites (Richardson *et al.* 2006).

The various definitions continue to be used but are vague although each is used to describe plants considered undesirable for one or many reasons. Arcioni (2004) presents an historical overview of Australia's changes in cultural values since 1788 and how this has affected the definition of the term 'weed'. Her article follows changes in the definition of the term and shows how legislative and policy regimes retain elements of historical definitions. The Australian Weeds Strategy (2007) defines a weed as a plant that requires some form of action to reduce its harmful effects on the economy, the environment, human health and amenity. The definition still is subjective but clearly indicates the nature

Fig. 1. *Buddlja davidii* a garden escape that now occurs in dense populations, competing with our native vegetation.

Fig. 2. Chicory *Cichorium intybus*.

Fig. 3. Salsify *Tragopogon porrifolius*.

Fig. 4. *Papaver somniferum*.

of the plant, i.e. it has such a negative impact that something must be done about it, indicating its invasive nature. The definition also clearly distinguishes plants that pose a serious threat to a particular value(s) from plants that do not.

Why are weeds a problem?

Australia has about 25 000 native vascular plant species (New 2006) and over 27 000 species introduced from overseas (Groves *et al.* 2005). About 10% of the latter have become naturalised (Groves *et al.* 2005; Muyt 2001). Weeds are spreading faster throughout Australia than is possible to control (http://www.weeds.gov.au/weeds). Agricultural weeds alone are believed to cost Australia at least $4 billion annually in terms of management activities and lost production (http://www.weeds.gov.au/weeds). The monetary cost to the environment, human health and amenity is unknown. The effects of the weeds, however, is well documented (e.g. Adair and Groves 1998; Carr *et al.* 1992; Davies 1992; Groves *et al.* 2005).

Most commonly, weeds compete with desired plants for space, nutrients water, light and pollinators. Competition can be devastating as seen in Fig. 6, an infestation of Morning Glory *Ipomea indica* in a rainforest in Fiji, and in Fig. 7, where Bracken *Pteridium esculentum* is overtaking pastureland in Scotland. Such extreme infestations of weeds have been reported for Australia as well (Muyt 2001). In bushland, such infestations obviously change species composition (and decrease biodiversity), vegetation structure, and ecosystem services, e.g. the habitat and floral resources offered to fauna, but may also affect ecosystem functions, e.g.

Fig. 5. Paterson's Curse *Echium plantagineum*.

Fig. 6. Infestation of Morning Glory *Ipomea indica* in Fiji.

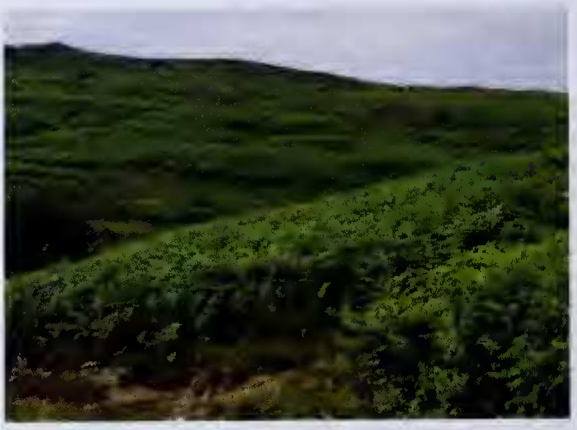

Fig. 7. Bracken *Pteridium esculentum* overtaking a paddock in the Moors of Scotland.

biogeochemical cycles such as the water and nutrient cycles, and alter the natural fire regime. Adair and Groves (1998) and Humphries *et al.* (1991) have documented such effects, and others, as a result of environmental weed invasions in Australia. It stands to reason that the biogeochemistry of agricultural land also can be affected by weeds when they occur in large numbers, for example, with Paterson's Curse and Serrated Tussock *Nassella trichotoma*. Water holding capacity, pH and nutrient status all are likely to change when a particular weed occurs in high numbers, as would evapotranspiration rates of an area and, thus, humidity, which can cause an increase in fungal pests. Large weed infestations in agricultural land can cause environmental ramifications; weeds can influence the type of invertebrates likely to inhabit the area, affecting the foraging of birds.

Weeds, whether agricultural, environmental, garden or of other, disturbed sites may be toxic or irritant or pose some other danger to animals or humans; they may be unpalatable or palatable but be low in nutrients - cattle can starve on Serrated Tussock (Osmond *et al.* 2008). Weeds may harbour diseases, insect pests or vermin. They can impede regeneration of desired plants through allelopathy, by interfering with dispersal of propagules or suppressing their germination simply because of their physical presence. Weeds can dilute genetic purity through hybridisation (many agricultural weeds are closely related to crop plants) block and redirect waterways, alter sedimentation rates of water bodies, damage structures, and reduce aesthetic appeal.

Weeds can contaminate agricultural products, interfere with harvesting operations, and interfere with recreation facilities. As well as decreasing plant biodiversity, faunal biodiversity also may be decreased as the ecosystem structure and function fauna require may be altered, forcing them to migrate or die. Either way, they become locally extinct.

What enables weeds to become problematic?
Both intrinsic and extrinsic factors facilitate a plant becoming problematic. Intrinsic factors relate to characteristics of the weed itself; extrinsic factors relate to characteristics external to the plant, e.g. characteristics of a situation or anthropocentric nature – e.g. humans have decided the plant is unwanted for some reason so it is a weed. Intrinsic characteristics that make a plant a weed often are shared by 'pioneer' species, early successional species that recolonise an area following disturbance. If a pioneer species of one country is introduced into another, it is likely to become a weed in the new country (Buchanan 1989). There is no suite of intrinsic characteristics that relate only to plants that become weeds, hence it is difficult to identify definitively which introduced plant may become an invasive weed and which will not; however, a number of broad characteristics can be identified that enables determination of the likelihood of a plant to become an invasive weed. Such a plant will have one or more of the following characteristics:

- tolerance/adaptability to a wide range of climatic conditions;
- tolerance/adaptability to a wide range of soil conditions;
- rapid growth;
- short reproductive cycle;
- high seed capacity;
- ability to reproduce vegetatively and/or by other asexual means;
- longevity of seeds and asexual propagules - e.g. dormancy;
- effective dispersal mechanisms;
- no special environmental requirements for germination of seed or asexual propagules;
- pollination is by wind or non specialised visitor;
- ability to alter soil conditions, including allelopathy and nitrogen fixaton;
- advantageous growth habit;
- ability to alter susceptibility of an area to a disturbance regime;
- ability to stabilise/destabilise the substrate of an area;

Each of these intrinsic properties is a more complex factor than at first appears. High seed capacity, for example, can be divided further. Plants may have a high seed capacity because they can produce seed when they are still very small, or are growing in very poor conditions; they may flower profusely and, as they have no specialist pollinator, produce many seeds; they may flower and produce seed continuously while they grow, rather than in a single reproductive effort. Any of these abilities alone or in combination may be coupled with a short reproductive cycle, thus seed of a plant may germinate and progeny may grow, flower and set seed while the parent is doing likewise.

Extrinsic factors may include: the state of the environment to which the plant is introduced, the absence of a predator, the fact that it is widely cultivated and, thus, is provided with many point-sources over a broad geographic range from which it can escape, the abundance of pollinators or presence/abundance of dispersal agents. There are many external factors that can facilitate a plant becoming a weed. Most commonly, it is humans that do so and a later section of this paper, which takes a brief look at Australian weed introductions, particularly demonstrates this.

There are a number of generalisations (compiled from Buchanan 1989; Muyt 2001 and Scott 2000) that can be used to predict whether a community or area will be prone to weed invasion:

- invasion of weeds is most likely after disturbance;
- the greater the degree or frequency of disturbance, the greater the degree of invasion;
- the greater the diversity or cover of the natural (or desired) community, the less likely weeds will invade;
- the smaller the reserve or area in question, the more prone it will be to weed invasion;
- the greater the fragmentation/isolation of an area, the more prone it will be to weed invasion;
- the greater the perimeter of a reserve or area, the more prone it will be to weed invasion;
- the nearer a propagule source of weeds, the more prone an area will be to weed invasion; also,
- biotic influences such as grazing by animals on some plants and not others can allow the latter to flourish.

It must be noted that exceptions to the rule may well occur and that there has been much debate concerning some of them. For example, Loreau *et al.* (2004) present a review of the concept that the greater the degree of disturbance the greater the degree of invasion. The concept became well accepted in the 1950s but was seriously challenged in the 1970s. Since then, results of experimental manipulations of weed

introductions into areas of increasing biodiversity have supported the original concept. Disturbance, however, is a natural occurrence for many communities. Hobbs and Huenneke (1992) review the interactions between disturbance, diversity and weed invasion, and conclude that the problem arises when there is a change in the natural regime of the disturbance. Unfortunately, it would be difficult to find any area where the original regime is extant. Weed invasion is here to stay and land managers must choose wisely when designating funding towards management programs.

Categories of weeds

Twenty weed species are so invasive and have such detrimental impacts on primary production, the environment, society and the economy, and have such potential for spread, that they have been designated Weeds of National Significance (WONS). These weeds cause problems on such a large scale and are so devastating that coordination is needed among all levels of government, organisations and individuals whose responsibility it is to manage them. These include *Lantana camara* (Fig. 8) and *Salvinia molesta* (Fig. 9). There is a strategic plan for each WONS which explains the strategies and actions needed to control the weed. Each WONS has a Management Coordinator and a National Management Group/Steering Committee to oversee implementation of the strategic plan. Half the WONS are garden escapes (Groves *et al.* 2005).

Other categories of weeds include those on the National Environmental Alert List, Sleeper Weeds, Northern Australian Quarantine Strategy (NAQS) species, species targeted for eradication, species targeted for biological control and state and territory noxious weeds.

Weeds on the Alert List are in early stages of establishment, thus distribution in Australia is limited, but the species have a high potential to become major threats to the environment. At this stage it is thought that eradication or containment programs can be successful. There are 28 Alert Weeds. Horsetails *Equisetum* spp. (Fig. 10) are on the alert list. These are primitive, herbaceous plants that do not produce flowers. They are more closely related to ferns than flowering plants. They are highly invasive and are allelopathic, producing an inhibitory substance that prevents the growth of other species. Morover, they are toxic to livestock as they contain alkaloids causing a syndrome, equisetosis,

Fig. 8. *Lantana camara*, a Weed of National Significance, can alter the fire regime of an area.

Fig. 9. *Salvinia molesta*, a Weed of National Significance that can blanket waterways, change water chemistry and kill the plants and animals beneath it.

Fig. 10. *Equisetum* sp. a weed on the Alert List.

which is sometimes fatal (http://www.weeds.gov.au). Horses, cattle and sheep are particularly sensitive and can die within a few hours if they eat large amounts. On the other hand, *Equisetum* has long been known as a herbal medicine (Cheung and Li 1985; Le Strange 1977), used as a diuretic, internally for ulcers and haemorrhages and externally for skin eruptions. A number of outbreaks occurred in the past which show that horsetails have the potential to be invasive e.g. from an Adelaide plant nursery in the 1950s and in the Mt Coot-tha Botanic Gardens in Brisbane (http://www.weeds.gov.au).

Environmental Sleeper Weeds are those that do not appear to be threatening but pose a potential threat through the ability to spread rapidly after such natural events as flood, fire, drought or other change in environment. Agricultural Sleeper Weeds are naturalised species that occur in small areas but, potentially, could spread rapidly and widely resulting in significant, detrimental impacts on agriculture.

NAQS species are those targeted by the Australian Quarantine Inspection Service. Northern Australia has a unique quarantine risk because of its vast coastline and sparse population. It is vulnerable to foreign vessels that bypass the usual quarantine checks at Australian borders, and migrating birds and wind currents may carry new pests to Australia. Without a high level of monitoring, pests that enter or have entered the area can reproduce and disperse rapidly and widely.

Noxious weeds are declared as such through enactment of legislation in each state or territory. It is applied to particularly invasive species that need active management to reduce their impact. A species may be declared noxious in one state or territory but not in another. Even within a state or territory, a species may be declared noxious in one locality but not another. Species targeted for eradication from Australia are exotic and potentially can cause serious problems at the national level to primary industry, the economy and the environment. Eradication programs are cooperative efforts between the Australian Government and state and territory governments.

Species are targeted for biological control through a cross-jurisdictional government process that requires much research.

Much more information about these types of weeds, the problems they cause and their management strategies can be found on http://www.weeds.gov.au.

Another important category of weed is the Garden Thug (Randall 2001). These are naturalised species that Randall considered were particularly invasive garden plants. Randall presents a rather extensive list of thugs (close to 1000) that gardeners would do well to avoid. One hundred and seventy of these were declared noxious within at least one state or territory by 1999. Gazania (Fig. 11) is an example of a garden thug.

Australia's weed introductions: a brief glimpse

Plant invasion can be divided into three stages (Groves *et al.* 2005):

- the introduction stage, which begins when a new species arrives in a region;
- the naturalisation stage is where plants are able to reproduce naturally without cultivation; and
- the invasive stage is where naturalised flora spread widely.

When they interfere with the economy, environment, human health and amenity they are termed weeds.

Approximately two thirds of Australia's naturalised flora was introduced deliberately as ornamentals. Most of the remaining flora was introduced as fodder, culinary, hedge or medicinal plants, in that order of importance (Groves *et al.* 2005). A wide variety of people have been guilty of introducing pest plants to Australia: seafarers stopping by in their travels, colonists, Acclimatisation Societies, industry, scientists and more.

Macassan seafarers brought Tamarind *Tamarindus indica* from the South Celebes to the beaches of the Northern Territory in the 18th century, when they made their annual voyage to collect edible sea-slugs (Adair and Groves 2005; Low 1999). At one stage, the Tamarinds were historic markers of Macassan campsites but, since they have become naturalised and spread further afield, it is no longer possible to

Fig. 11. *Gazania* sp., a Garden Thug.

use them as such (Low 1999). The Tamarind is the first known plant invader (Adair and Groves 2005). It is unknown whether the Tamarind was deliberately planted or simply grew from the seeds left behind as the waste product of a food source. Explorers of the 18th and 19th century planted vegetables, fruits and grains as well as pasture plants (Low 1999). Some of these have become environmental weeds, e.g. Sisal *Agave sisalana* which was planted to provide fibre for production of sails. In some areas it now forms thick, prickly, impenetrable thickets on beaches (Low 1999). The Olive *Olea europaea* was first introduced into Australia in 1805 and now is naturalised in South Australia, New South Wales, Victoria and Western Australia. It is variously classed as a weed, noxious weed, naturalised, garden escape, environmental weed and cultivation escape and is proclaimed in South Australia, except when planted for domestic or commercial use (Parsons and Cuthbertson 2001).

Acclimatisation Societies, determined to introduce as many plants as possible to Australia, were responsible for the introduction of a number of weeds. One such plant was the Blackberry *Rubus fruticosus L. agg.*, which was heavily promoted by members of acclimatisation societies in the 1860s (Low 1999). It was claimed that Blackberry provided edible fruit, controlled erosion along streams and was ideal as a hedge plant. It is now a WONS and in the 1980's was estimated to cost $41.5 million annually for New South Wales, Tasmania, Victoria and Western Australia (Agriculture and Resource Management Council of Australia and New Zealand 2000). This did not take into account economic impacts on natural ecosystems or allow for all states and territories, thus was an underestimation. Gorse *Ulex europaea* was widely encouraged for planting as hedge plants on farms in the early 1800s (Richardson and Hill 1998) as a cheap alternative to fencing. Its thorns were recommended as able to keep stock confined. Its prolific seeding was recommended as a cheap means of maintaining and extending hedges. Beneath an adult plant, there are up to 40 000 seeds/m^2, or 400 million seeds/ha, at any one time (Ivens 1978). It was naturalised by 1889 (Richardson and Hill 1998). Today, Gorse occurs throughout temperate Australia, spread over 23 million ha. Potentially, Gorse may spread over 87 million ha, including most of the arable land of Victoria, Tasmania, coastal South Australia and a lot of south-west Western Australia (Thorp and Lynch 2000). This estimate is based on climatic data.

Agricultural scientists recommend introduction of plants for a wide variety of reasons including phytoremediation of land affected by secondary salinisation, genetic improvement for drought resistance, and stabilisation of soil erosion (Carr *et al.* 1992).

Accidental introductions, of course, also occurred – as contaminants of grain and other seeds, in pots containing fruit trees, contaminants in hay, mud on boots. Robert Brown listed 20+ weeds when he visited Sydney between 1802 and 1804 (Low 1999).

People introduce plants for many different reasons, for building of homes, for economic reasons, for security in the amount and reliability of their food source, for fuel, fodder and medicine. But, psychological reasons also play a part. On the whole, people prefer familiarity, familiar foods, familiar working materials and familiar surrounds. For this reason initial immigrants brought with them favoured plants from their home country. The greatest diversity of plants, however, was ornamental in nature (Groves *et al.* 2005). Such a strong need for comfort has been demonstrated repeatedly among colonies world-wide, particularly after food, fuel and medicinal resources have been secured (Mack 2001); however, this transplant of the homeland was not enjoyed by all. In 1881, Marianne North complained while travelling in Tasmania that 'The country was not in the least attractive to me; it was far too English' (quoted in Low 1999, p. 29).

Mack (2001) discusses the motivations and consequences of the human dispersal of plants and concludes:

> The composite consequence of these expressions of human necessity and choice has been the dispersal of tens of thousands of species into distant new ranges. Some species transported as the result of these expressions of human behaviour have become invasive; the number of such species belies their immense environmental and economic impact. In effect, deep-seated aspects of human behavior continue to determine the character, extent, and rate of the human-mediated transformation of the earth's vegetation. (p. 23)

Groves *et al.* (2005) in their much acclaimed *Jumping the Garden Fence* suggest (p. 73)

> for its own professional status, the nursery and gardening industry can no longer afford to be seen

to be selling invasive plants, as it has in the past and that

Removal of plant species from sale because of their known invasive properties will help overcome the past and present situations.

Responsible plantings by councils also should occur. In Victoria, there are some nature strips planted with *Lantana camara*, a WONS (pers. obs.). *Gazania*, a Garden Thug, is widely used for roadside plantings in Victoria and elsewhere (pers. obs). In South Australia, over 100 km of roadside vegetation is swamped by *Gazania* (pers. obs), in the locality of Berri, a town in the Riverland region and 238 km north-east of Adelaide. It would be better if local councils used plants indigenous to the area for roadside beautification projects and much education of the public and nursery trade is required to encourage the selection and promotion of garden plants that are not invasive.

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